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BY

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SIGNALLING FROM CAGES AT REST OR IN MOTION

By D. J. Parker and R. I. C. Manning

Ability to signal the hoisting engineer in shaft mines is of utmost importance from the standpoint of safety and economy. The problem of signalling from the cages and especially from the moving cages has received too little attention from mine operators; however, this problem has been given considerable thought and attention by at least one large metal-mining company in Utah which has devised successful, economical, and safe systems of signalling from the cage whether it is moving or at rest.

A Report of Investigations on "Methods used in Utah for signalling mine hoists from moving cages," by C. A. Allen, then a metal-mining engineer in the Bureau of Mines, was issued in June, 1920. As this report contains interesting history of systems of signalling from moving mine hoists, and describes several systems then in use, it is here quoted in full.

> The problem of signalling to the hoisting engineer from a moving cage in the shaft has been considered by many mine operators for a number of years. There are several methods in use in different mining districts, and so far as the writer is aware they have been further developed in Utah than in any other State. The latest installations are of interest because they use a very low-voltage circuit for the shaft wires and also because the wiring can be so arranged that the hoist can be stopped from the cage, if so desired.
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> The first installation in Utah was in the shaft of the Centennial-Eureka mine under the management of C. E. Allen. It was placed in operation in the summer of 1899, and has been in continuous and satisfactory operation for 21 years. The arrangement consists of two bare wires down the shaft carrying a current at 60 volts potential, with a device on the cage for making connection between the two wires. This device is simply a short piece of wire which is thoroughly insulated from the cage and is operated by a short lever. Whenever the cage rider wishes to signal the engineer he

1 - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: Reprinted from U. S. Bureau of Mines Information Circular 6161.

2 - Supervising engineer U. S. Bureau of Mines Salt Lake City Utah

3 - Associate mining engineer U. S. Bureau of Mines Mine Rescue Car No. 9 Butte Mont.

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pulls down the lever, forcing the short wire out against the two bare wires, thus making a circuit which rings the bell in the hoist-room. A similar device was placed in the Grand Central shaft at Mammoth, Utah, but was later abandoned. The cause of failure was reported to be that the shaft was very wet.

At a later date a system having the same general arrangement as that used in the Centennial-Eureka mine was placed in the shaft of the Eagle and Blue Bell mine at Eureka, but dry batteries were substituted, reducing the voltage to about 10 volts. This shaft is wet in places, bu no trouble has been experienced. The Eagle and Blue Bell mine is under the management of Imer Pett, of Salt Lake City, and several improvements on the method have been made by the mine electrician James Strang, in consultation with Leonard Wilson, of Salt Lake City. In order to give a better idea of the possibilities and application of the system, it should be stated that the hoist is a double-reel modern electric hoist with oil-operated clutches and brakes. The clutch and brake for each reel are actuated by different movements of the same control lever. The hoist has the usual safety devices, such as limit switches in the headframe, position switches for each reel, and ball-governor control. These safety devices are operated by what may be termed the control wiring, which is in series with a no-voltage release on the switchboard. Should the circuit in the control wires be broken, the no-voltage release acts, which cuts off the power and automatically applies the brakes. For example, if the cage should be pulled up to the limit switches, the circuit would be broken, automatically stopping the hoist. This arrangement of wiring for the safety devices is not materially different from that used on other electric hoists, and is mentioned here solely to show that opening the control circuit is all that is needed to stop the hoist.

In the Eagle and Blue Bell shaft there are two No. 4 bare copper wires, one on each side of the shaft guides. One of these wires is used for signalling from the levels, the second wire forming the return. The second wire is also used to make the circuit for ringing the bell from a moving cage.

As regards signalling from the cage, it may be assumed that there is only one bare wire in the shaft, this wire extending into the hoist-room and through an ordinary Western Union relay switch to the ground. On the cage is a battery of six dry cells inclosed in a piece of iron pipe for protection. One terminal of the battery is connected to the hoisting cable and is thus grounded through the hoist. The other terminal is connected with an ordinary push-button switch and a piece of curved copper plate which, by means of a small lever, can be pushed out against the bare wire. The push button is on the same lever. When the cage rider pulls the lever, at the same time pressing the button, current flows from the dry cells through the bare wire, through the relay into the ground, thence through the hoist cable back to the cells. The current flowing through the relay closes a separate electri-

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cal circuit, which rings the signal bell. The current for the bell circuit is supplied by 30 dry cells in the hoist room, but connection could be made with a direct power or lighting circuit.

The important feature of this arrangement is that the dry cells, placed on the cage, give a low-voltage current, only 10 or 12 volts, eliminating all possibility of danger, such as would be present were higher voltage used. Also, if the contact lever should be accidentally struck and contact made with the bare wire, the circuit would not be completed, because in order to close it the button must be pushed at the same time the lever is thrown. The use of the relay in the hoist room is also important, because it permits the use of a low-voltage current in the shaft and a higher voltage to ring the bell.

In order to stop the hoist from the cage by the same wiring system, it is only necessary to place in the control circuit of the hoist another relay so arranged that when the circuit is completed in the shaft, this relay will OPEN the hoist-control circuit. As soon as this circuit is open the no-voltage release on the hoist switchboard will be operated, cutting off the power and automatically stopping the hoist.

O. N. Friendly, general superintendent of the Judge Mining and Smelting Co., is installing a modification of the Eagle and Blue Bell system for use in the Daly-West shaft at Park City. It is planned to do all the signalling from the cage and have no signal arrangement on the levels except the flash or buzzer system for calling the cage. A Number 0 bare wire will be suspended in the shaft with insulators at every 4 feet. Instead of a hand lever to make contact against the wire, there will be a continuous contact with the wire as between an electric motor and trolley wire. Six dry cells will be placed on the cage as at the Eagle and Blue Bell shaft, and the relays and bell circuits on the surface will also be the same; push buttons will be used to close the circuit.

Double-deck cages are in use, and to make it possible for a cage tender to give signals from the cage while standing on the station at either side of the shaft, four push buttons will be used, two on each side of each deck.

By this method there is no possibility that anyone will signal the hoisting engineer except from the cage. It not infrequently happens that careless or ignorant employees signal the engineer when they do not know where the cage is, causing the engineer to move the cage when it should not be moved.

The outstanding feature of a system of signalling from the cage is the greater safety afforded persons when riding on the cage or when getting on it. The need of such a system is shown with particular force in the account of deaths in two metal-mine fires.

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In the Granite Mountain shaft fire, Butte, Mont., June 8, 1917 (U. S. Bureau of Mines Bull. 188, "Lessons from the Granite Mountain shaft fire, Butte," by D. Harrington), 20 minutes after the fire started just below the 2,400-foot level, two men were lowered into the shaft after first having given a signal to be lowered to the 2,200-foot level. The fire had burned out the signalling systems and no signals could be given from the shaft. As the cage descended the men could see the flames below them, and as they passed the 1,800-foot level they implored some men standing at the station to stop the cage; the signals could not be given, and the two men were lowered as far as the 2,200-foot level, which point the flames had already reached, notwithstanding the fact that the air flow in the shaft was strongly downcast. After waiting an appreciable period of time, and receiving no signals, the hoisting engineer hoisted the cage and found parts of it to be almost red hot and the men dead. An effective signalling system, operable from the cage, undoubtedly would have saved the lives of these two men.

In the Magma mine fire, November 24, 1927 (U. S. Bureau of Mines, Serial 2882, "Shaft fires - Magma mine," by E. D. Gardner and D. J. Parker), an Apache Indian cage tender was lowered into the fire region of the shaft and the cable of the cage burned apart, allowing the cage and the man to fall to the shaft bottom. If a signalling device had been on the cage operable while the cage was moving the cage tender very probably would not have lost his life.

The value of such a system is strikingly shown in another incident during the Magma fire. The shift boss and a cage tender were lowered to the 1,000-foot level, and apparently finding everything all right, signalled from the station with the electric-bell system to be lowered to the 1,500-foot level, but at the 1,200-foot level they encountered smoke. Apparently they were being lowered slowly as they were able to reach out of the cage, grasp the rope on the pull bell and signal to stop the cage and then to hoist the cage. The cage tender was overcome and had to be carried to fresh air by the shift boss. The ability to signal from the cage (by reaching out and grasping the pull rope) undoubtedly saved the lives of these two men. This incident emphasizes the utility and safety of a signalling system operable from the cage; the pull-rope system is good as an auxiliary device or for emergency purposes, but it has weaknesses and limitations especially in wet or deep shafts.

The Park Utah Consolidated Mining Co. has two systems of signalling from moving cages in three of their mines; both systems are reported to be successful and satisfactory, but they required years of experimentation before reaching their present successful workable state. The Park Utah Consolidated Mining Co. is probably the only company in the United States using this type of shaft-signalling in connection with the ordinary types of cages or skips, though in some mine shafts men and certain kinds of material are carried by elevators of the office-building type and having the usual ability to start or stop at any point in the shaft.

The installations at the Daly West and the Daly Judge shafts are similar. Both shafts are exceptionally wet, but this condition has not prevented the successful operation of the signalling system. The Daly West shaft is 2,200 feet deep. Details of the system

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for movement of men and supplies on cages used in these two mines are shown in Figure 1. A two-naught (00) trolley wire, suspended in the shaft, is secured by hangers placed 10 feet apart; the lower end is below the last station. The upper end of the trolley wire is connected to a 150-ohm Bonnell relay, B, which in turn is grounded to the hoist. An Edison 3-cell, 6-volt storage battery, C, is placed in a weatherproof box securely fastened to the outside of the cage. One battery terminal is grounded to the cage and the other terminal is connected to a pull switch, D, which when operated forces a steel pantagraph against the trolley wire. The circuit through the relay is completed and closes the circuit in a 110-volt alternating current line, ringing a single-stroke 10-inch bell, A. A lamp directly above the bell also lights when the circuit is closed.

The rotary pull switch, D, on the cage is provided with a shaft which can be rotated from each of the two decks of the cage. When the switch cable is pulled, the shaft is rotated, and contact with three finger spring brushes is made through three fiber rings with brass inserts which are fastened to the switch shaft. As the shaft is rotated a movable curved galvanized iron plate or pantagraph attached to its end is forced in contact with the trolley wire. The pantagraph does not remain in contact with the trolley wire except during signalling, but if contact should be made accidentally, the bell does not ring, as no contact is made through the rotary switch on the cage.

On one of the installations of the system a device is provided to keep the light above the bell turned on after a signal has been given until the cage is moved. The object of this arrangement is to eliminate the possibility of the engineer's mistaking a repeated signal for a signal from the skip in the other compartment of the shaft. The device consists of two magnetic switches, connected in series, and a drum directly connected to the shaft-hoist indicator. The drum, which is synchronized with the indicator, is fitted with fiber rings and brass inserts which make contact with flexible brass fingers.

The cost of installing the system is $2,500 for each compartment and the maintenance is about $25 a month, including labor. The life of the battery is about two years. The system is checked daily by the electrician, the inspection requiring about 8 minutes. The storage battery is charged and watered every two weeks, the pantagraph is replaced about once a month, and the trolley wire is cleaned annually. During two years of constant operation the only damage to the system due to falls of rock or other material was a broken pantagraph.

Accurate data kept over a period of two years show this system to be cheaper in installation and upkeep than the level signalling formerly used; therefore it is not expensive, but it is not safe practice to have only one signalling method in any shaft. There should be one or more methods of signalling from every level, one or more by electricity and one or more by a speaking tube or telephone and by a pull bell, in addition to the cage signalling system. Under no conditions should there be fewer than two means of signalling in any shaft, and, if feasible, there should also be a telephone system with wiring in a different shaft or drill hole to constitute a third possible means of transmitting messages or signals.

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In the No. 2 shaft of the Park Utah mine of the same company another method of signalling from moving cages is in successful operation. This shaft is 600 feet deep and is exceptionally wet. The entire installation, including the hoist, which is of the Bollen pulley type, is underground. The cage is counterbalanced with a 9,000-pound Anaconda skip; the hoisting speed is 400 feet a minute.

Details of the installation are given in Figure 2. The source of power is in the engine room. Electric power at 2,300 volts alternating current is reduced to 110 volts, one end of this circuit being grounded to the hoist; the other end of the circuit is further reduced to 24 volts alternating current. About halfway down the shaft a No. 4 parallel conductor cable is connected to the 24-volt circuit; the other end of the cable is connected to the bottom of the cage, enough cable being used to allow for the maximum travel of the cage.

On each of the two decks of the cage, two pull switches, similar to those used at the Daly West mine, are so placed that the cager may signal from either side of each deck. A buzzer is also placed in the signal line, and it buzzes when the bell in the engine room rings. Each of the pull switches has one terminal grounded to the cage, and the buzzer is connected in series with them. Although 24 volts are used in the system, as few as 1½ volts may be used with the present type of electric cable. The Park Utah No. 2 shaft installation has been in operation for two years and has been satisfactory.

CONCLUSIONS

Signalling the hoisting engineer at shaft or slope mines is an important feature in safe and efficient haulage or hoisting and is a feature rarely considered in mine-hoisting installations; there should be at least two, preferably three, independent signalling systems, and there should by all means be a signalling system operable from cages whether moving or at rest. Such a system may be fully as economical as the usual systems operable only from the levels, and in some instances the signalling from the cage can be made more economical than a similar system of level signalling. The outstanding feature of the method allowing of signalling from the cage is its greater safety; however, the greater and more positive control of hoisting may easily effect economies that will offset the cost of the installation.

The cost is trivial when prevention of accidents or the saving of human life is considered. Nevertheless, the cost of one severe accident or of one life lost through failure to provide a signal on the cage will more than equal, in cold cash expended in compensation, the cost of the installation or its maintenance and operation for several years. Many instances could be cited of lives lost or jeopardized, particularly in coal mines, by lowering men into water-filled sumps; innumerable accidents and deaths have occurred during ordinary working periods due to the necessity of signalling from the level and afterwards walking or running to the cage, or of reaching out from the cage to signal from some fixed point on the level; lack of ability to signal from the moving cage during ordinary working time has resulted in numerous accidents, many resulting in death and many others in heavy destruction of property. The ability to signal from a moving cage during shaft fires in

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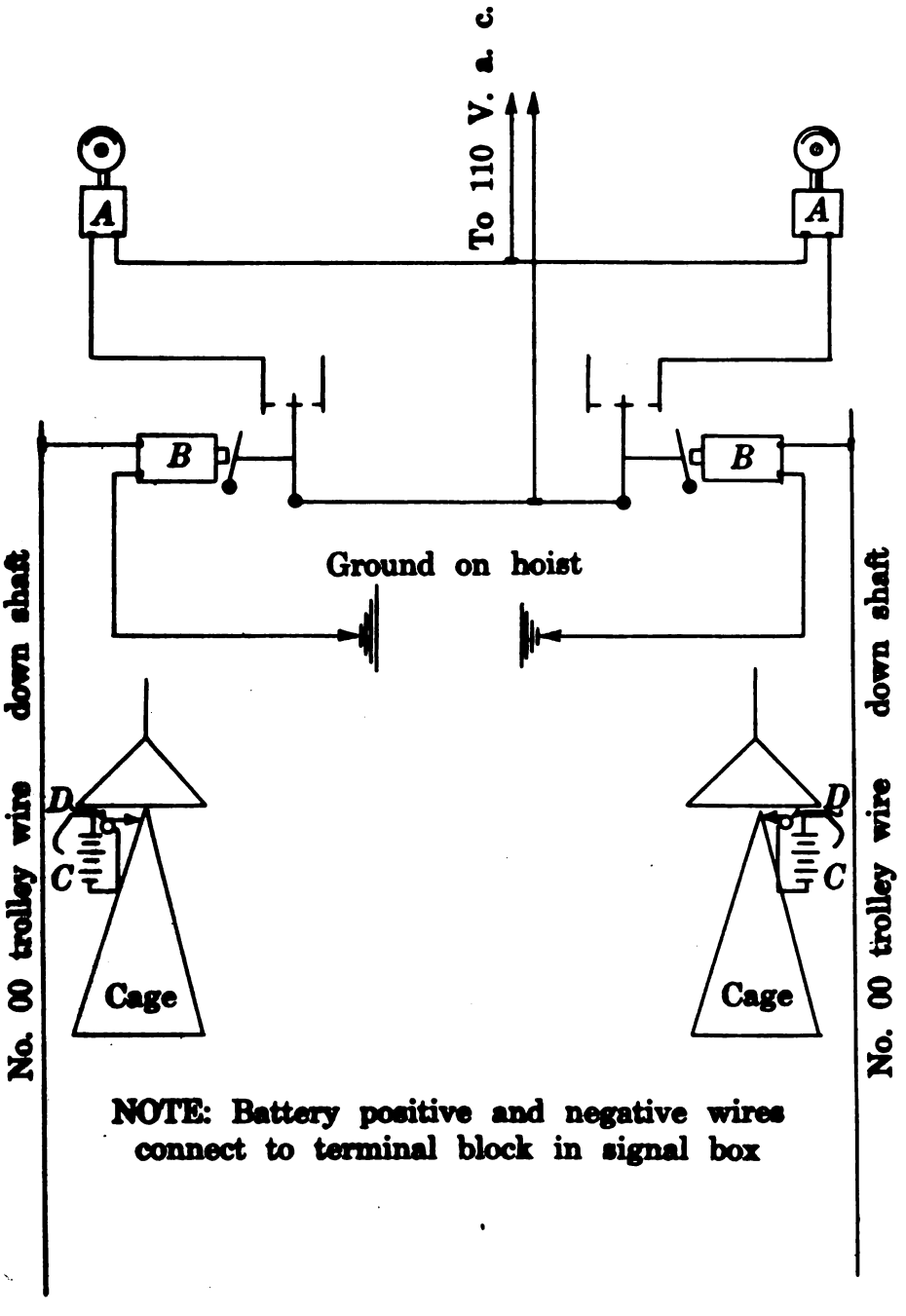

Figure 1. — Wiring chart for hoist signal system. *A*, Signal Electric Co. single-stroke 110-volt, a. c., 10-inch bells; *B*, Bonnell 150-ohm relays; *C*, 3-cell, L-20 Edison batteries; *D*, cage switch

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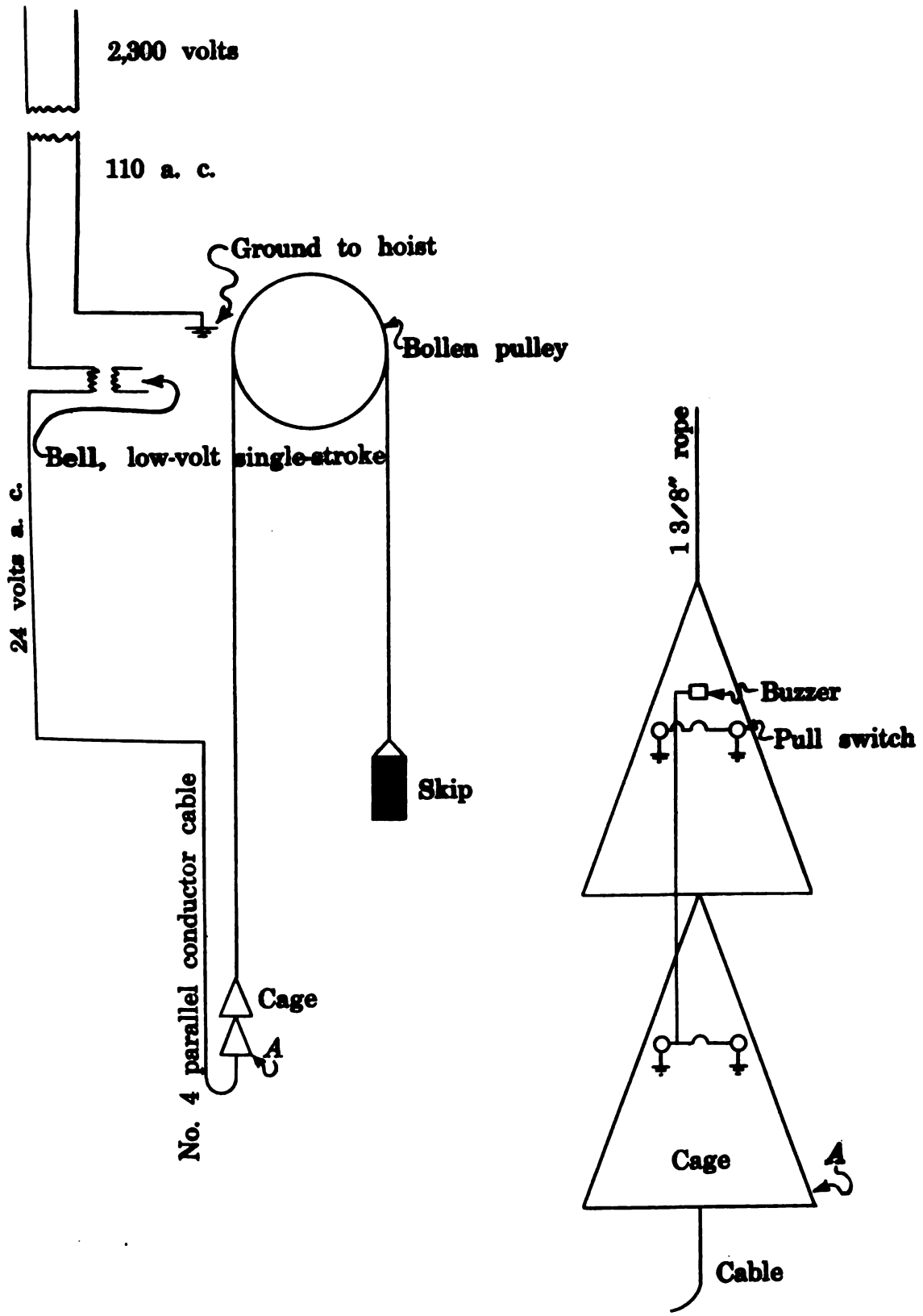

Figure 2. — Signal system, No. 2 shaft, Park Utah Consolidated Mining Co.

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metal mines is a safety feature which in itself should require its universal use; many such fires when first discovered could be extinguished, if men could control the moving cage by definite signals.

There is no doubt that the many definite safety features involved in the ability to signal from moving cages should appeal alike to coal and metal mine operators wherever men are transported in vertical or inclined shafts. Suitable methods of signalling from the cage or trip, whether moving or at rest, should be required wherever men must travel on them.

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